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Eucalyptus deglupta Blume Kamarere

Myrtaceae Myrtle family

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Eucalyptus deglupta Blume, known as kamarere in Papua New Guinea, bagras in the Philippines, and leda in Indonesia *(35),* is a tall and graceful tree with attractive, multicolored bark (fig. 1).

HABITAT

Native Range

Lying between 9° N. and 11° S., the native range of kamarere covers Mindanao of the Philippines; Sulawesi, Ceram, and Irian Jaya of Indonesia; and Papua New Guinea, including New Britain *(10, 20,* fig. 2). It is one of only two *Eucalyptus* species whose native range extends beyond Australia (the other is *E. urophylla* S.T. Blake) and is the only one that does not occur naturally in Australia *(4, 41).* Kamarere has been planted throughout the humid Tropics, particularly in the Solomon Islands, Fiji, Samoa, Taiwan, Malaya, the Ivory Coast, Costa Rica, Honduras, Brazil, Cuba, and Puerto Rico *(15, 38).*

Climate

Natural stands of kamarere grow in areas where the annual rainfall ranges from 2000 to 5000 mm *(41),* but most of the commercial stands are found where the mean annual rainfall is between 2500 and 3500 mm *(10).* Precipitation in these areas tends to be uniform throughout the year, with only a few months averaging less than 150 mm *(20).* Prolonged dry seasons rarely occur *(10),* and relative humidity is usually high: 70 to 80 percent *(19).* At low elevations, mean monthly maximum temperatures vary from 24 to 33 °C, whereas at elevations above 300 m, the mean monthly temperatures range from 13 to 27 °C *(10).* Nowhere in the natural range is the species exposed to frost.

Soils and Topography

Kamarere grows well on deep, moderately fertile sandy loams, but it also grows on volcanic ash and gravelly soils *(35).* The species can be found growing in its native areas from sea level to 1,800 m *(26).* The best stands develop on river terraces and banks less than 150 m above sea level *(10).* Good soil drainage is required *(21).* On poor soils and at higher elevations, the trees have much slower growth. Kamarere often colonizes new alluvial deposits, landslide areas, and new volcanic ash *(10, 19).*

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Associated Forest Cover

Kamarere generally reproduces in pure stands *(19).* Occasionally, however, it forms an association with *Octomeles sumatrana* Miq., an aggressive secondary species *(43).* As stands pass maturity, they are invaded by primary forest species such as *Pometia pinnata* (Taun), *Dracontomelum mangiferum* Bl., *Homalium* spp., *Celtis* spp., and *Pterocarpus indicus* Willd. *(19).*

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting.—Kamarere begins flowering at an early age, usually within 3 or 4 years in plantations *(19).* The cream-colored flowers are borne in the terminal or auxiliary panicles of umbels, with three to seven flowers each *(10).* Flowering occurs in most months of the year *(41).* The seeds ripen in 3- to 5-mm long capsules in 5 to 6 months *(19, 35).*

Seed Production and Dissemination.—Each seed capsule contains 12 to 48 seeds *(2),* which make up about 2 percent of the capsule's dry weight *(41).* The seeds are small, about 15,000 to 18,000 per gram *(10).* From 2,000 to 4,000 seeds per gram are usually viable *(39).* However, the germination of high-quality seeds may be as high as 90 percent *(41).* Nine 10-year-old seed trees in Malasia pro-

Figure 1.—*Fifteen-year-old kamarere in a Puerto Rican plantation.*

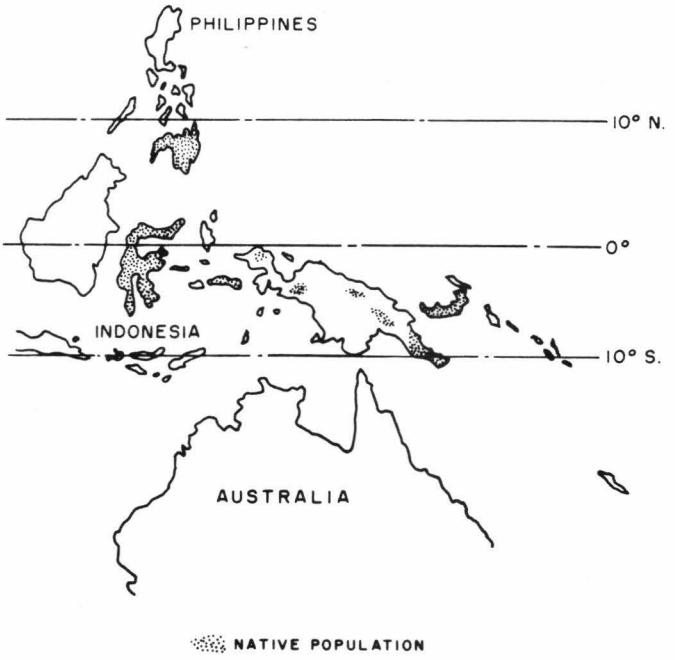

Figure 2.—*The native range of kamarere.*

duced an average of 87 g of seeds per tree from a single picking *(5)*. Capsules may be picked green and will open to release the seed after 2 or 3 days of drying in the sun *(41)*. After drying, seeds may be stored for up to 2 years by refrigerating in airtight containers *(39)*. Kamarere seeds have wings, and this, in addition to the small size of the seeds, enables them to drift into nearby disturbed areas. Seeds will travel a little more than the height of the tree in a 10 km/hr wind *(20)*. Water is the most important vehicle for seed dispersal because the best kamarere sites are on river flood plains *(19)*.

Seedling Development.—Germination of kamarere is epigeal *(10)* and takes place in 4 to 20 days *(39)*. The best temperature for germination is 35 °C *(32)*. No pretreatment of seeds appears to be necessary. Sowing seeds in shaded and glass-covered germination trays is typically the first step in seedling production. Seeds will germinate on a moist surface, but a dusting of fine sand or sieved loam is recommended *(41)*. Sand, sandy loam soil, sawdust, and ground sphagnum moss substrates have given about equal germination results *(23)*. The germination media is usually sterilized in order to avoid damping-off disease *(41)*. Seedlings are transplanted to tubes or pots when they have two or three pairs of leaves above the cotyledons. Bare-root stock and striplings (bare-root seedlings with the leaves removed) are not used because survival is very low *(2)*. Seedlings reach 20 to 30 cm, plantable size, 3 to 4 months after germination *(41)*. Shade should gradually be reduced from full shade during germination, to one-quarter shade, to full sun by the end of the nursery phase *(19, 33)*. As seedlings of kamarere are very susceptible to drought (wilting), planting should be done during a rainy period. After a month in the field, seedlings are able to withstand ordinary moisture stress *(14)*. Successful site preparation procedures include plowing furrows *(1)* and burning slash left in place from logging *(40)*. When initially controlled, other woody vegetation is usually quickly overtopped, but if grass becomes a problem, it must be controlled in the first and second years by herbicide spraying or hoeing around the young trees *(41)*. Fertilizer placed near, but not in contact with, roots at the time of planting is sometimes used to help seedlings dominate weedy competition *(33)*. Early growth is very fast. From 4.5 to 6 m height in the first year is normal in New Britain *(19)*.

Vegetative Reproduction.—Kamarere coppices too poorly to be used as a method of regenerating plantations *(20)*. Cuttings of kamarere, however, readily root. Treated with hormone paste and misted, more than 99 percent of the cuttings from seedling stems will root, beginning about 5 days after treatment *(11)*. Root cuttings may also be used to reproduce kamarere *(39)*. Grafting by the patch method is effective enough to be used in tree breeding *(13)*.

Sapling and Pole Stage to Maturity

Growth and Yield.—Kamarere is ranked among the world's fastest growing trees *(35)*. It is also capable of growing to an extraordinary size. Individuals have been recorded up to 72 m tall and 1 m in diameter at breast height (d.b.h.) *(29)*. The greatest annual height increment is usually observed during the first year and gradually decreases over the next 25 or 30 years. Figure 3 illustrates height growth potential in plantations from a number of locations around the world. Only the best plantation for each age at each location is noted. Site index curves for planted kamarere have been prepared for the islands of Sabah *(6)* and Mindano *(34)* and for Costa Rica *(36)*. However, kamarere is a site-sensitive species; when planted on poor sites, kamarere may grow so slowly that it will never produce usable timber. This has occurred in nutrient-poor upland sites in Puerto Rico. Diameter growth is dependent

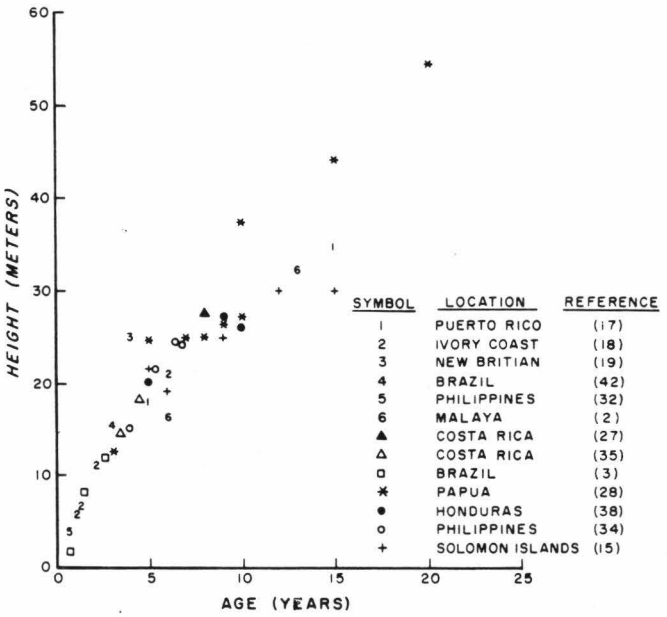

Figure 3.—*Mean height at various ages for a number of exceptional kamarere plantations around the world.*

on spacing, but annual increments of 2 to 3 cm/yr are not uncommon over a pulpwood rotation (5 to 12 years).

One natural stand of kamarere harvested in New Britain contained 940 m^3/ha of timber volume *(19)*. Another plantation in New Britain reached a standing volume of 520 m^3/ha in 20 years *(15)*. A yield table based on site index and stand age *(34)* and equations for single-tree volumes based on diameters and heights *(27, 36)* have been prepared. Mean annual volume increments from plantations on good sites range from 15 to 37 m^3/ha (fig. 4). If desired, thinning harvests may begin at the end of 1 year for stakes and continue through posts, pulpwood, and sawlogs as the plantation ages. The rotation age for pulpwood, the most important product from plantations, is from 5 to 12 years *(15)*. Rotation ages for sawlogs in Sabah are 16 to 18 years *(6)* and in Papua New Guinea, 25 years with thinnings at 5, 10, and 15 years *(15)*.

Rooting Habit.—Seedlings aggressively develop both vertical and horizontal root systems, and the taproot branches at an early age. Mature trees have vertical, branched taproots and a shallow lateral root system whose size extends from one-fourth to one-third the height of the tree *(10)*. The root development depends, however, on soil conditions and competition between trees. The roots are usually not a threat to sidewalks and foundations. Ectotrophic mycorrhizae form in root hairs of kamarere *(3)*. On unstable soils and river alluvia, the tree often develops buttresses 3 to 4 m high *(10)*.

Reaction to Competition.—Kamarere is shade intolerant. Full overhead light is required for development past the seedling stage *(41)*. The species will not reproduce under shade and needs natural or artificial openings. Kamarere typically forms pure stands; either it finds suitable conditions, reproduces in great numbers, and dominates, or it fails completely. In initial trials, 2- by 2-m spacing resulted in trees stagnated by the end of the second year *(12)*, so wider spacings were adopted. Currently, a 4- by 4-m spacing, without thinning to a pulpwood rotation, is probably most common *(15)*. Refilling vacancies caused by mortality must be done before the end of the first growing season, or new seedlings will be suppressed by older trees nearby *(41)*. A basal area of 26 m^2/ha was reported for a 20-year-old plantation in New Britain *(15)*. A 15-year-old mixed *Eucalyptus* spp. plantation in Puerto Rico supported a total basal area of 38 m^2/ha, 12 m^2/ha of which was kamarere. Mean annual basal area increments of 2.6 and 2.8 m^2/ha were reported for 4- and 9-year-old plantations in New Britain and Java respectively *(19)*. The crowns of young trees are conical with a definite leader and horizontal branches *(10)*. The leaves are held horizontally, which maximizes the interception of sunlight *(20)*. As the trees age, apical dominance is lost, and the crowns become flat topped. Closed stands have an average crown length equal to one-fourth to one-third the average tree height *(10)*.

Damaging Agents.—There are several serious pests of kamarere. A ring borer (hapialid moth) and a carpenterworm (cossid moth) are the two major insect pests in Sabah *(6)*. These borers significantly reduce the value of trees as sawlogs. Losses of up to 40 percent of the seedlings in some plantations have been inflicted by the giant snail *(Achatina fulica* Bowdich) that eats the bark, and seedlings may snap off from the weight of these snails *(19, 41)*. The snails can be controlled with metaldehyde baits. Termites are also severe pests of kamarere *(19)*. They attack the tree from the seedling stage through maturity and sometimes consume the entire heartwood. Preplant burning helps to reduce termite activity *(40)*. In Papua New Guinea, the larva of the cossid moth, *Zeuzera coffeae* Nietner, bores into the cambium and sapwood of young trees, leaving them susceptible to wind breakage. Three percent of the trees in one plantation were affected *(15)*. The stem girdler, *Agrilus opulentus* Ker., attacks suppressed trees in Papua New Guinea *(24)*. In the Philippines, the varicose borer, *Agrilus* sp., kills trees in some plantations *(37)*. Heart rot probably affects kamarere in all parts of the world. An investigation of a plantation in Papua New Guinea found 38 to 83 percent of the trees affected, but amounts present in each tee were generally so small that pulpwood quality was not effected *(22)*. In Central America and Brazil, serious problems with leaf cutting ants *(Atta* spp.) have been reported *(26, 36)*. Tip necrosis in the Solomon Islands, caused by the coreid bug *(Amblypelta coophaza cocophaga* China) was shown to be reduced by clearing vegetation between *Eucalyptus* spp. trees and introducing the ant *Oecophylla smaragdina (25)*.

Kamarere has the thinnest bark (3 mm) of all eucalyptus and consequently is extremely sensitive to fire *(30)*. All fire should be excluded from kamarere plantations. A canker disease associated with wounds, particularly machete cuts from vine removal, is common in parts of Puerto Rico. Ornamental trees in Puerto Rico frequently have limbs broken in gusty winds. Seedlings of kamarere have been reported to survive temperatures of -2 °C, but they die at lower temperatures *(19)*.

SPECIAL USES

The heartwood of kamarere is reddish brown and coarse grained. The sapwood is white or pale pink. Kamarere wood dries easily with little degrade and moder-

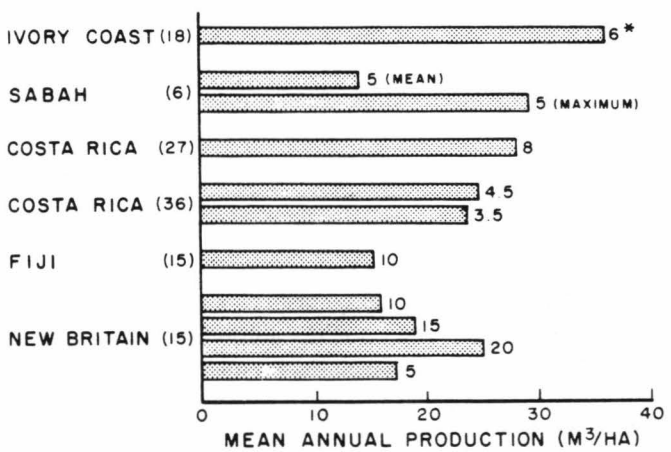

Figure 4.—*Mean annual volume production measures at the indicated age (*) of kamarere plantations in several countries (references in parenthesis).*

ate shrinkage (3.9-percent radial and 7.8-percent tangential) *(7)*. It has a typical ribbon grain and good luster. The wood saws and machines easily except for some splitting on quarter-sawn faces *(10, 19)*. It also polishes and glues well. Specific gravity is greater for old forest-grown material (0.45 to 0.65 g/cm^3) than for young plantation material (0.35 to 0.40 g/cm^3) *(7)*. The heartwood is resistant to *Ly c-tus* spp. (powder post beetles) *(14)*, but is not termite resistant. The wood is not durable in contact with the ground *(35)*.

Kamarere wood is used for furniture, molding, flooring, construction lumber, and boat building *(14)*. Around the world, most of the planted kamarere is intended for pulpwood. Kamarere wood makes a strong sulfate pulp that can be bleached to a high brightness *(6)*. Kamarere is also used to a limited extent for firewood and for making charcoal *(26)*. The aromatic oils of kamarere have been characterized, but occur in such low quantities, 0.2 percent in the foliage *(29)*, that they are of no interest commercially. Due to its very attractive bark and quick growth, the species is frequently planted as an ornamental and shade tree.

GENETICS

The genus *Eucalyptus* contains more than 500 species *(29)*. Kamarere, *E. deglupta* Blume (botanical synonym, *E. naudiniana* F. Muell.) has been placed in the series Degluptae with *E. raveretiana* F. Muell and *E. bachyandra* F. Muell. *(31)*. Density of the wood is correlated with 70 percent of the variation in wood quality and is highly heritable *(9)*. Selection should be for greater and more uniform wood density. A number of countries have provenance and selection programs underway *(16)*.

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